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The effect of TV viewing on children's obesity risk and mental well-being: Evidence from the UK digital switchover

Adrián Nieto[a,*], Marc Suhrcke[a,b]

[a] Luxembourg Institute of Socio-Economic Research (LISER), 11 Porte des Sciences, Esch-sur-Alzette 4366, Luxembourg
[b] Centre for Health Economics, University of York, Heslington, York YO105DD, UK

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ABSTRACT

We examine the effect of screen-based activities on obesity and mental well-being for children, using a large survey dataset representative of the UK population and an event study model that exploits exogenous variation in the entry date of the digital television transition in the UK. The digital transition increased the number of available free television channels from 5 to 40, leading to a rise in television viewing time. Our results show that receiving access to digital television signal considerably increases the mental health total difficulties score among children, and that this impact grows over time. We also find suggestive evidence that the digital transition could have increased BMI for children. Underlying the net effects appear to be decreases in participation in social and physical activities.

1. Introduction

Obesity and mental health problems among children have considerably increased during the last decades in most high-income countries (OECD, 2019a; 2019b).[1] This raises important societal concerns, first, in light of the associated disease burden itself, but also beyond, due to adverse effects on educational performance (Currie, 2009; Currie and Stabile, 2006), future labour market outcomes (Fletcher, 2014; Lundborg et al., 2014; Smith, 2009) and life expectancy (Frijters et al., 2010), among others. Television (TV) viewing, a very popular (in-)activity among children and adolescents in most high-income countries, has been commonly hypothesized to be one underlying driver of poor health during childhood, both in terms of physical health especially concerning children's weight (Swinburn and Shelly, 2008) and mental well-being (Dickson et al., 2018). Yet, as plausible as these consequences may be, the literature on the effect of exposure to television on obesity and mental-wellbeing has struggled to identify a meaningful causal relationship (Biddle et al., 2017; Dickson et al., 2018).

As recent data shows, children spend a substantive share of their free time in front of the television. For example, in the UK, 94% of children watched TV for an average of 13.25 h per week in 2018 (Ofcom, 2019). Given such magnitudes, it is important to understand the causal effect of TV viewing on mental and physical health, an ambition which - for several reasons – is not met easily. First, the (widely) observed correlation between TV viewing and overweight and mental (ill-)health could also be the result of reverse causality: children who feel mentally low - or that are overweight - may be less motivated or able to be socially and physically active and, hence, turn to TV viewing more often. Second, there could be third factors either unobservable or not accounted for in

* Corresponding author.
E-mail address: adrian.nietocastro@liser.lu (A. Nieto).

[1] Appendix A.1 provides some descriptive background evidence on the international as well as UK-specific mental health and obesity context in children and adolescents.

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the empirical work (e.g parental preferences and education styles, socioeconomic background) that simultaneously affect both sides of the observed relationship (Nakamuro et al., 2015).

In the present study, we seek to provide evidence on the causal effects of TV watching on child mental health and obesity, as well as on the underlying mechanisms. We do so by exploiting a natural experiment design offered by the "digital television transition" that occurred in the UK between 2008 and 2012, forcing in stages every television transmitter to stop broadcasting analogue signal and start transmitting high power digital signal. Several important changes occurred at the time of transition from analogue to digital signal, including an increase in the number of television channels from 5 to 40, the possibility of watching television content in several languages, the introduction of multimedia services, and a higher definition.

As a result, the switchover was one of the biggest changes in British television history (DigitalUK, 2012). The digital switchover did not exclusively occur in the UK, but also in many other countries world-wide.

Some previous research has used the digital transition in Italy to explore the effect of television on voting attitudes (Barone et al., 2015) and crime concerns (Mastrorocco and Minale, 2018), and the digital transition in the UK to examine the effect of television on academic outcomes (Nieto, 2019). Besides digital transition reforms, earlier work has exploited variation in the timing of the introduction of TV infrastructure to provide evidence on the impact of childhood TV exposure on educational performance test scores in the US (Gentzkow and Shapiro, 2008), and variation in reception of TV programs to assess short and long-term effects of TV on academic and labour achievement (Kearney and Levine, 2019).

The digital transition in the UK provides for an adequate natural experiment to study the causal impact of television on health outcomes for two reasons. First, the digital transition was implemented in stages by two independent organizations, based on the physical characteristics of the British television transmitters. These had been constructed in the 1960s and 1970s, hence reducing the likelihood that the switchover is correlated with unobserved determinants of children's health outcomes. Second, we are able to exploit fine-grained geographical variation in the switchover timing across more than 40,000 geographical units.

We merge the switchover information with two other datasets. The first one contains aggregate panel data on total TV viewing time and shares of the different TV content categories at the region–week level. The second dataset consists of the first eight waves of the Understanding Society survey. This is a high-quality longitudinal survey dataset representative of the UK population, providing information on the health outcomes and socio-demographic characteristics (among others) of children that have been interviewed annually since 2009. Using this information, we construct a large panel dataset. Throughout the analysis, we estimate an event study model that exploits the fact that children live in areas that received access to digital signal at different dates and allows to show the dynamic effect of exposure to television on child health.

Our paper adds in at least three main ways to the literature on the effect of screen-based activities on mental health and overweight. First, we provide causal evidence on the effect of exposure to television on child mental well-being and obesity, using the digital television transition in the UK as a natural experiment, combined with a rich longitudinal, nationally representative survey dataset. Second, we examine potential heterogeneity in the effects across relevant sub-groups of children with different socio-demographic characteristics, to examine whether mental well-being and body weight of some groups of children are particularly affected by exposure to television. Third, we explore plausible mechanisms operating behind these effects, including changes in the frequency with which children engage in social, physical, and extracurricular educational activities.

Our results demonstrate a harmful influence of exposure to television on the mental health of children and provide suggestive evidence that TV exposure could increase their BMI as well. We first show that television viewing time does not change in the years prior to the switchover but does increase immediately after its implementation, with the effect increasing over time. For health outcomes, we show that, in the years prior to the switchover, there is no change in children's mental health and BMI. However, we find that, very shortly after receiving access to digital television, there is a strong increase in children's mental health total difficulties score (TDS), and that this effect increases over time. We also find suggestive evidence that children's BMI could have increased as a result of the digital transition. Taking into account the effects of the switchover on TV viewing time, mental health and BMI, we estimate that one more hour of TV viewing time per week during a year increases children's TDS by 3.53% and potentially raises their BMI by 1.04%. Finally, we show that the digital transition reduces mental well-being and potentially increases overweight via decreasing children's involvement in social and physical activities, but not through changes in children's eating habits, perceptions about their appearance, or involvement in extracurricular educational activities.

The paper is structured as follows: Section 2 reviews the literature on the effect of television on health, Section 3 explains our natural experiment as well as identification strategy and Section 4 describes the data we use. Section 5 presents and discusses our findings, and Section 6 explores plausible mechanisms. Lastly, Section 7 provides concluding remarks.

2. The relationship between TV viewing and children's overweight and mental health

While there exists a significant and extensively reviewed literature that has empirically analysed the relationships between TV viewing and either overweight (Biddle et al., 2017; Ghobadi et al., 2018; Tripathi and Mishra, 2020; Zhang et al., 2016) or mental health (Dennison et al., 2016; Dickson et al., 2018) in children and adolescents, the existing evidence is, as the here-cited reviews underline, dominated by either cross-sectional evidence that is remarkably mixed in terms of the size and significance of the estimated relationship, or based on small-scale, hard-to-generalize experimental intervention studies. Taken together, this leaves the question of a causal, population-level effect of TV viewing still widely open.

Much of the early work focused on either cross-sectional or in rare cases a limited longitudinal design. For instance, in what appears to be the first empirical study of its kind, Dietz and Gortmaker (1985) used data from two (mostly) cross-sectional rounds to show a significant, but in the authors' judgement "small" association between TV watching and child obesity.[2] An important advance in the direction of more extensive, yet somewhat regionally constrained, longitudinal analysis was by Hancox et al. (2004), who used longitudinal data from a rich birth cohort of over 1000 children born in one town in New Zealand in 1972-73, to show that weekday TV viewing was associated with higher future body mass index (BMI). Similar results were found for the US by Boone et al. (2007) and Danner (2008), using nationally representative datasets from adolescents and Kindergarten children cohorts, respectively, and for Australia by Cleland et al. (2018), using a prospective cohort of Australian children. More recently, Tahir et al. (2019) established a dose-response relationship between hours of TV viewing in childhood/adolescence and BMI at age 18 and in adulthood, among females in the US. Other studies contradicted or at least attenuated the Hancox et al. (2004) results, finding a weaker and sometimes insignificant association between TV viewing and BMI (DuRant et al., 1994; Hammer et al., 1993; Katzmarzyk et al., 1998; Nakamuro et al., 2015).

Alongside the observational studies, a set of experimental, generally small-scale intervention studies have been conducted (Buchanan et al., 2016). According to the systematic review by Buchanan et al. (2016), the existing evidence indicates that reductions in screen time may decrease BMI from -0.09 to -0.44 kg/m^2, suggesting that limiting television viewing time may help prevent child obesity (Robinson, 1999). Buchanan et al. (2016) also note, however, that while the existing experimental evidence does exist for children, it remains scarce for adolescents (aged 13+ years), which is the age where screen time increases most notably.[3] It is also important to bear in mind that the experimental studies are subject to at least two important limitations. First, these studies are typically based on very small sample sizes and short follow-up post-interventions, and as tends to be characteristic of experimental studies more generally (Duflo et al., 2007) are often implemented with special care, compared to how they would be implemented in real-world circumstances. Second, it is not hard to imagine that small-scale, experiment-based effects may differ from real world impacts of population-level, secular changes in TV viewing, which only become visible if the treatment is scaled up to a larger population or extended over a longer duration. This may work in both effect-enhancing and diminishing directions: for instance, if TV channel availability and viewing becomes increasingly common, there may be social multiplier effects (Christakis and Fowler, 2007) that could reinforce the population-level impact on obesity (or mental health), compared to the sum of any individual effects TV viewing would have in an experimental, individual-level setting. Alternatively, population increases in TV viewing may intensify social awareness about the negative implications of screen watching on health, which may lead to individuals adopting types of behaviour that may cushion the negative implications of television on health. Taken together, these limitations compromise the external validity and generalizability of small-scale studies. By estimating the effect of exposure to television on mental health and BMI in a population-wide study setting, we are able to – in contrast to the existing multiple studies using small-scale surveys of a selective population sub-group – capture potential general equilibrium effects to be had from scaling up the "treatment" to an entire population.

Several potential mechanisms may explain the effect of TV viewing on obesity. First, TV watching is a sedentary activity that might substitute the time children spend being physically active (Jenvey, 2007). For the UK, Sandercock et al. (2012) showed a graded, negative association between higher screen time and lower free-time physical activity in a cross-sectional sample of 10–15 year olds. Similarly, Tammelin et al. (2007) found screen time to be negatively correlated with physical activity for Finnish adolescents. Second, watching TV may reduce the resting metabolic rate, i.e. the amount of calories burnt by the body when at rest (Klesges et al., 1993). Lastly, television viewing may increase energy intake (Crespo et al., 2001; Van den Bulck and Van Mierlo, 2004), through the behavioural influence of TV advertising targeting children and adolescents to increase their fast-food, sugary beverages and alcohol consumption (Andreyeva et al., 2011; Avery et al., 2017; Chou et al., 2008; Hastings et al., 2003; Powell et al., 2017; Saffer and Dave, 2006).

Regarding mental well-being, TV viewing has been commonly associated with aggressive behaviour (Huesmann et al., 2003; Johnson et al., 2002; Nakamuro et al., 2015), irregular sleeping time (Johnson et al., 2004; Thompson and Christakis, 2005), anxiety (Bryant et al., 1981), depression (de Wit et al., 2011) and attentional problems (Christakis et al., 2004). The suggested mechanisms behind the potential adverse mental health outcomes comprise: TV watching increasing physical inactivity and/or sedentary time, which in turn harms mental well-being (Harvey et al., 2010; Lechner, 2009; Lubans et al., 2016); TV viewing contributing to weight gain and unfavourable body composition, provoking weight-based bullying, teasing, stigmatization, and ultimately poor mental health (Nikolaou, 2017; Russell-Mayhew et al., 2012); and the sedentary behaviour associated with TV viewing increasing the intake of unhealthy food and beverages (Chou et al., 2008; Hobbs et al., 2015), which harms children's and adolescents' psychological mood (Jacka and Berk, 2007; van Strien et al., 2013).

[2] A similarly influential, early study was by Gortmaker et al. (1996), who established a statistical link between TV viewing hours in adolescents and the probability of being overweight, using (mostly) 1990 data.

[3] In light of the scarcity of experimental intervention studies on young adolescents, as highlighted by Buchanan et al. (2016), combined with the generally mixed findings in the above-mentioned observational data research, there does not appear to exist a consensus on the precise role played by the age of children or adolescents in affecting the relationship between TV viewing and obesity (the same applies to the mental health effects of TV viewing.) On the one hand, it is plausible to assume that because younger children are subject to greater and more effective parental control, they may on average be less exposed to TV viewing than adolescents (Biddle et al., 2014), and, hence, they would be less likely to suffer adverse physical or mental health consequences. On the other hand, epidemiological research has shown that while the odds of being overweight continuously increase as children grow older, the particularly sensitive time for children to develop their longer term weight trajectories seems to be at very young ages (i.e. below age 7) (Geserick et al., 2018). From this perspective, any TV viewing in the very early years may have more damaging effects in younger, particularly susceptible children. In contrast, as for mental health, it appears to be the older children and adolescents that face bigger mental health challenges, compared to younger ones (Blakemore, 2019).

3. Natural experiment and identification strategy

3.1. Digital television switchover

The digital transition involved the upgrade of every TV transmitter in the UK in order to switch off the transmission of analogue signal and start the provision of high-power digital signal. The digital switchover was one of the biggest revolutions in the history of the British television market, as it gave digital television access to millions of households for the first time in their lives and equipped them with several important improvements. For example, the digital television signal increased the number of television channels from 5 to 40, allowed individuals to watch some television programs in multiple languages, offered multimedia services, and provided a higher definition.[4] To be able to watch digital television, it is not only necessary to receive digital signal but people also need to install a set-top box in their TV device, which could be bought for approximately 30 pounds and which was subsidized for economically disadvantaged individuals by the UK Government.

Two independent organizations were in charge of the digital television transition implementation: Ofcom and DigitalUK. Ofcom is the media regulator in the UK and DigitalUK is a non-profit organization. They implemented the switchover process based on the physical components of the British television broadcasters, which had been built in the 1960s and 1970s.

The switchover process took place at different dates in the different television transmitters during the period of 2008 and 2012. There are 1235 television transmitters in the UK and it is common for individuals to receive television signal from more than one television transmitter. This generates strong geographical variation in the timing of the digital switchover, which we exploit across more than 40,000 Lower Layer Super Output areas. These are small statistical areas with an average population of 1500.[5] Fig. 1 displays the variation we use in the analysis on the switchover process during the period of 2008–2012.

The changes brought about by the digital switchover notably increased television viewing time. Fig. 2 shows that television viewing time did not change much in the years prior to the switchover commencement, but that it rapidly increased after the start of the digital transition. Television viewing time remained higher during the digital transition period and steadily decreased upon its completion, probably due to the increased use of tablets and the introduction of internet-based streaming services such as Netflix, Youtube and Amazon Prime video (Ofcom, 2019). Not surprisingly, Fig. 2 shows that the TV viewing share of the analogue television channels fell during the digital transition period due to the higher supply of digital television channels. The TV viewing shares of the traditional channels also fell prior to the switchover process start because part of the population already had access to a higher number of TV channels before the switchover start.

Lastly, Figure 3 shows that television content did not change considerably during the period of analysis. Here, we classify television content into eight different categories: entertainment, educational programmes, cultural content, novelas, children content, news, documentaries and other.[6]

3.2. Empirical strategy

We estimate an event study specification that exploits variation in the date when children receive access to digital signal to estimate the dynamic effect of exposure to television on mental well-being and BMI. Our baseline model is the following:

$$y_{i,r,t} = \alpha + \sum_{\tau \neq -1} \beta_\tau 1[\tau = t - t_r] + \theta X_{i,r,t} + \lambda_t + \zeta_r + \zeta_r t + \varepsilon_{i,r,t} \tag{1}$$

where $y_{i,r,t}$ is the outcome of interest of child i, who lives in LSOA r, in year t. Our two main outcomes of interest are the mental health total difficulties score and BMI of child i in year t (see Section 4 for definitions). $\sum_{\tau \neq -1} 1[\tau = t - t_r]$ is a set of dummies equal to 1 if τ periods have passed or are left at year t relative to the digital transition deadline in LSOA r, which is denoted by t_r. We include event dummies for the three years preceding the switchover to study parallel trends in our outcomes of interest before the switchover occurrence. We also include event dummies for the six years after the switchover occurrence and a dummy for seven years or after to account for the dynamic effect of the switchover on health. We use as baseline period $\tau = -1$, meaning that our coefficients of interest will show the effects of the years relative to the digital television transition date compared to the year prior to its occurrence. We control for a number of time-varying covariates at the individual level, such as gender, a set of age dummies, the logarithm of household income, the number of members, bedrooms and cars in the household, and whether children live in a rural or urban area. We denote this set of socio-demographic controls by $X_{i,r,t}$.[7] λ_t is a set of year dummies that control for non-linear trends in the outcome variables common across children over time. We also control for LSOA fixed effects, which are denoted by ζ_r, to

[4] Despite the number of improvements, the most important change was the increase in the number of TV channels that people could watch from 5 to 40. Having the possibility of watching the same television program in multiple languages may not have increased substantially the interest of children in that program, but it could neither have reduced the interest of children in that program.

[5] The name of the geographical units we use in Scotland and Northern Ireland are Data Zones and Super Output Areas, respectively. These are equivalent in size and population to LSOAs in England and Wales.

[6] Figures 2 and 3 provide information representative for the UK population. In Appendix A.2, we provide similar descriptive evidence for children. We show that the patterns of TV viewing and TV content over the period of analysis for children are similar to the whole UK population ones. We do not provide descriptive evidence on the shares of the traditional channels for children because this data is not available.

[7] It is important to control for a set of age dummies as this allows to account for a non-linear relationship between BMI/mental health outcomes and the age of children.

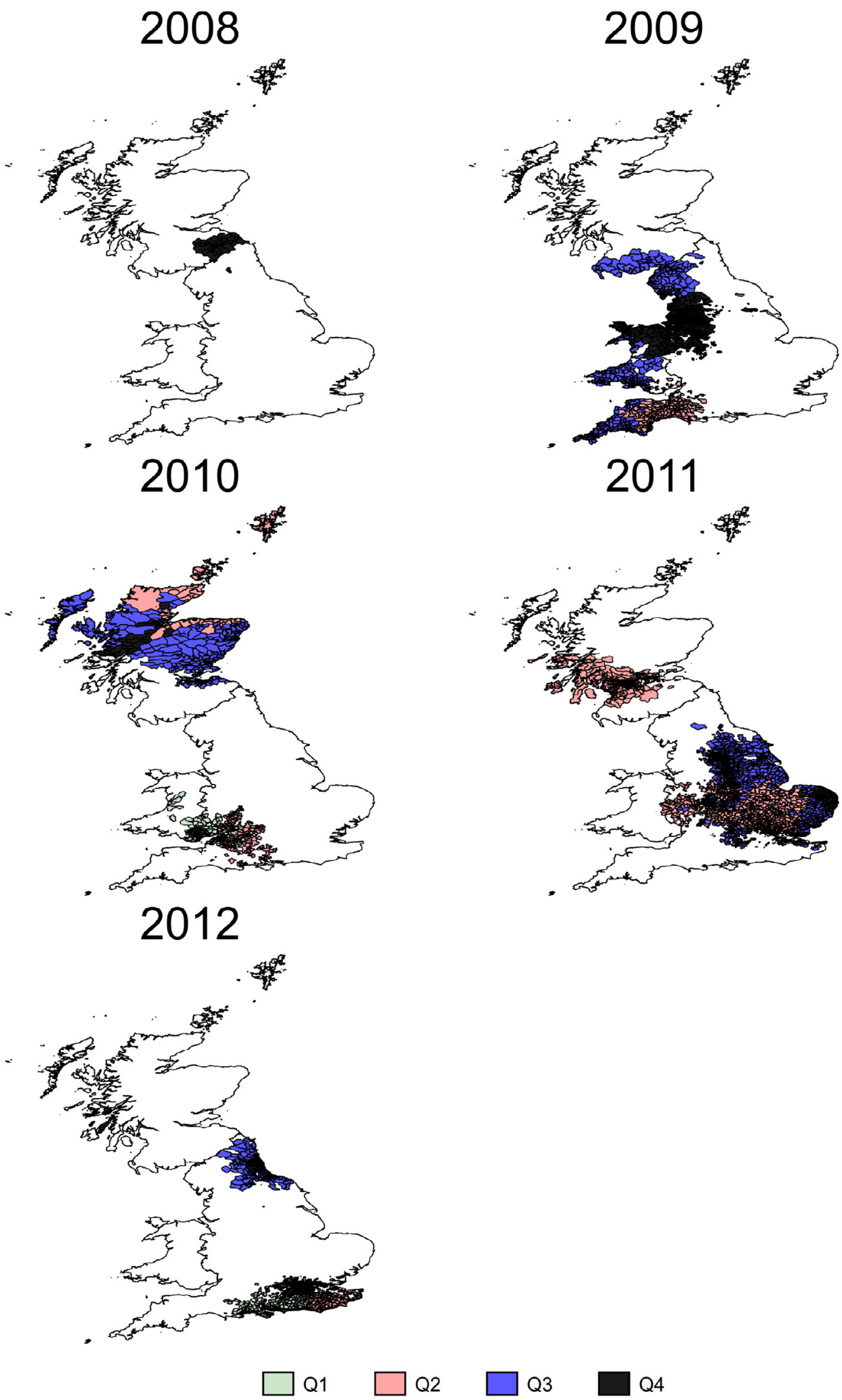

Fig. 1. Switchover Process. The figure shows the staggered introduction of the digital switchover in the UK. By 2012, all regions in the UK had obtained access to digital television signal. Albeit not shown, the digital television transition also occurred in Northern Ireland during the period of 2008–2012.

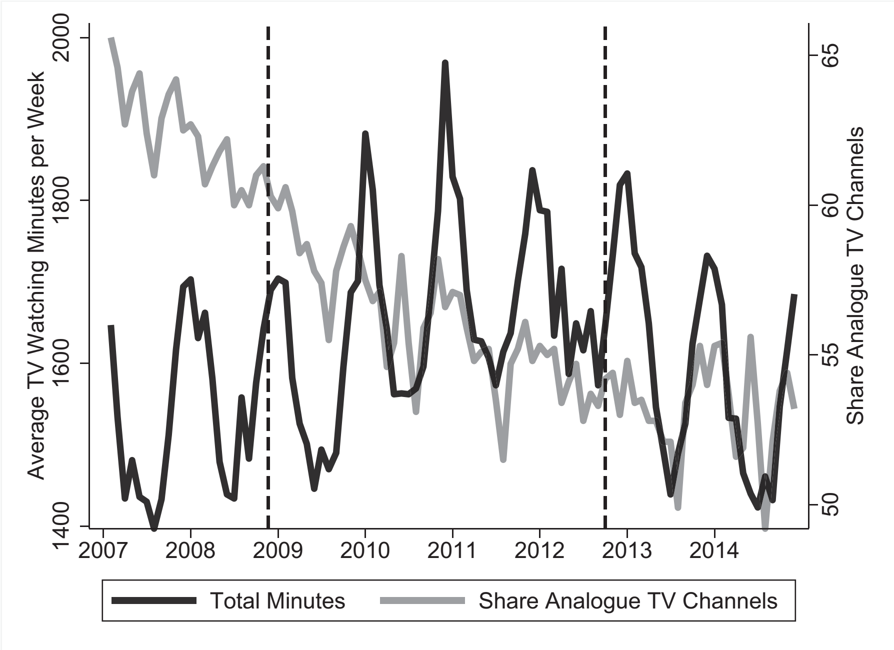

Fig. 2. TV Viewing Time and TV Shares. The figure uses data from the Broadcasters Audience Research Board to present the average television viewing time of the UK population per week and the share of the channels that could be watched via analogue television signal during the period of analysis.

account for time invariant unobserved determinants of the mental health and weight of children at the LSOA level, and for regional trends, denoted by $\zeta_r t$, to account for the possibility that the different LSOAs may be following different health trends over time, which may bias our event study estimates if not taken into account (Angrist and Pischke, 2008). Despite the inclusion of time-varying covariates, year dummies, LSOA fixed effects and trends in the analysis, we still have enough variation in $\sum_{\tau \neq -1} 1[\tau = t - t_r]$ as the digital switchover took place in the different LSOAs at different dates. Finally, $\varepsilon_{i,r,t}$ is a time-varying error at the child level. We cluster standard errors at the LSOA level.[8]

4. Data

4.1. Switchover data

We use information on the dates when the digital transition occurred at the LSOA level in the UK, which we web-scrape from the DigitalUK website. The dataset on digital transition deadlines also contains information on the transmitters that provide digital television signal to each LSOA, the quality of the signal, and the type of transmitter. There are two types of television transmitter: principal transmitters, which generate television signal, and relay transmitters, which receive television signal from the principal broadcasters and repeat it to areas that cannot receive television signal from the principal transmitters. We link this information with two additional datasets that we describe below.

4.2. TV viewing data

We first merge our information on the switchover dates at the LSOA level with an aggregate panel dataset that contains TV viewing information at the week level for each of the 13 TV regions in the UK, using mappings between both geographical units. This provides us with important variation in the switchover dates across the different TV regions in the UK. These areas were set by ITV, which is a public television network, so that television providers could manage the broadcast of regional TV content, such as local news or weather information. As the unit of the dataset is the week-region level, and as we use the sample period from 2007 to 2014, this provides us with 4655 week-region observations in our analysis of TV viewing, and we do not impose any sample restriction. The dataset was provided by the Broadcasters Audience Research Board (BARB), and it provides rich information on television viewing,

[8] Appendix A.3 presents the baseline estimates for mental well-being and BMI clustering standard errors at alternative levels, such as the household and Government Office region level.

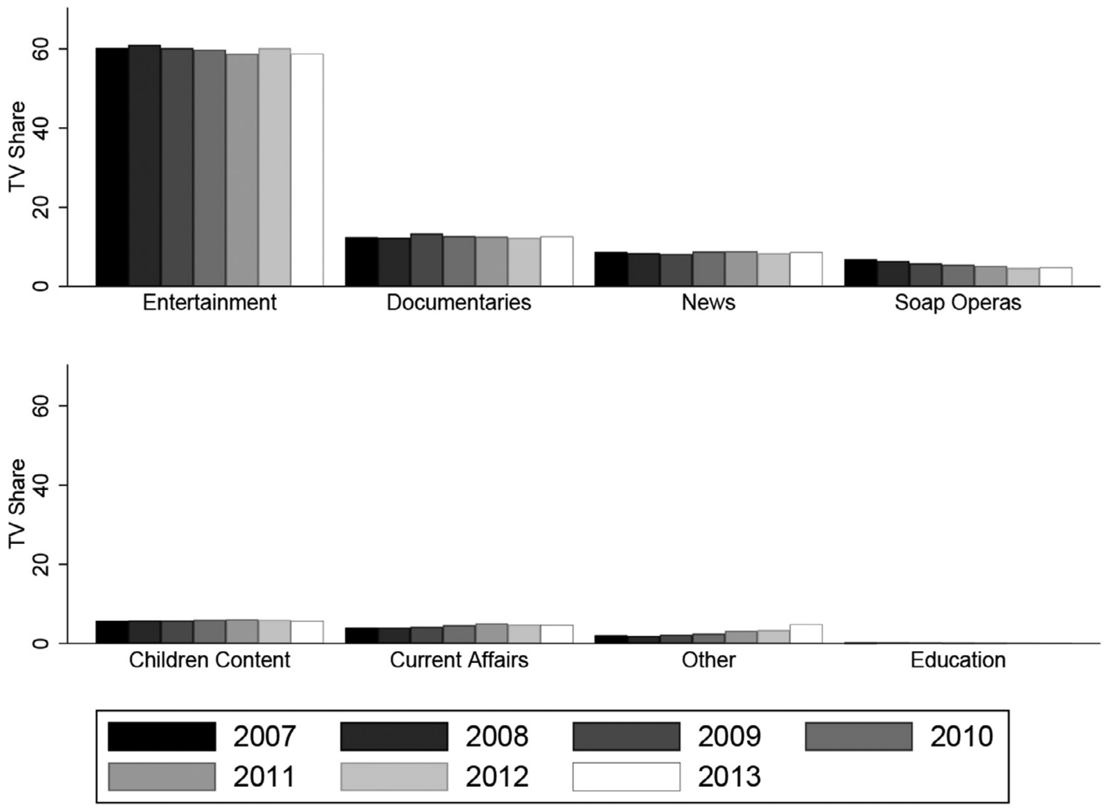

Fig. 3. TV Content. The figure uses data from Ofcom to present the share of each television content during the period of analysis. In particular, we show the proportion of television viewing time that individuals dedicate to the entertainment, documentaries, news, soap operas, children content, current affairs, education content and other genres.

including the average weekly TV viewing time in regions and the share of the following TV content categories in a region and week: (i) arts, (ii) children content, (iii) documentaries, (iv) affairs, (v) weather, (vi) soap operas, (vii) music, (viii) educational content, (ix) entertainment, (x) leisure, (xi) drama series, (xii) political content, (xiii) cinema movies, (xiv) religious content, (xv) sports, (xvi) TV movies, and (xvii) other content. We have this type of information for several age groups, including children aged 4–15. During the observation period, children aged 4–15 watched television for 949.43 minutes per week on average.

4.3. Understanding society

We also link our information on the digital switchover with data from waves 1–8 of the youth questionnaire of the Understanding Society survey (University of Essex, Institute for Social and Economic Research, 2019a), which is a large longitudinal survey representative of the UK population that has followed children aged 10–15 on a yearly basis since 2009. The dataset permits linking children across different waves, allowing us to build a panel dataset containing yearly information on the health outcomes, time use and socio-demographic characteristics of children. Regarding health outcomes, the youth questionnaire of the Understanding Society survey contains information on the height, weight and BMI of children. The Understanding Society survey also contains yearly information on the mental health difficulties of children, providing scores on whether they have: (i) emotional, (ii) relationship, (iii) conduct, and (iv) hyperactivity problems. Each of these components are measured on a scale ranging from 0 to 10 with higher values indicating greater mental discomfort and can be summed into an overall mental discomfort score, which can range from 0 to 40. We have information about the BMI of individuals for different survey years than those that we have mental health information for. Throughout the paper, we include all observations we can use for each outcome variable in the analysis to maximize the statistical power we can have. This leaves us with a sample of 13,379 and 4979 individual-year observations in the analyses of overall mental health discomfort score and BMI, respectively. As the number of children we use in the mental health and BMI analyses is 8251 and 3376, respectively, we are able to observe children for an average of 1.62 and 1.48 times in these analyses, respectively.

The Understanding Society survey also provides rich information on the socio-demographic characteristics of children, such as their age, gender, ethnicity, household income and household size, as well as on whether they live in rural or urban areas. Using special licence data from the UK data service (University of Essex, Institute for Social and Economic Research, 2019b), we also observe

Table 1
Descriptive Statistics.

	Sample	Boys	Girls
Age	12.58	12.57	12.58
	(1.68)	(1.67)	(1.68)
Non-white British	0.24	0.24	0.25
	(0.43)	(0.43)	(0.43)
HH Speaks English	0.96	0.96	0.96
	(0.19)	(0.19)	(0.19)
Religious	0.60	0.58	0.62
	(0.49)	(0.49)	(0.49)
Net HH Income	3507.72	3591.35	3421.68
	(5833.18)	(7608.62)	(3076.40)
Rural Area	0.24	0.25	0.23
	(0.43)	(0.43)	(0.42)
N bedrooms	3.47	3.48	3.46
	(0.93)	(0.93)	(0.92)
N cars	1.48	1.48	1.47
	(0.86)	(0.85)	(0.88)
Has siblings	0.91	0.92	0.90
	(0.29)	(0.28)	(0.30)
Household Size	4.51	4.53	4.48
	(1.36)	(1.35)	(1.36)
N Children	2.21	2.22	2.20
	(1.06)	(1.05)	(1.08)
BMI	19.96	20.03	19.88
	(4.79)	(4.82)	(4.76)
Mental Difficulties Score	10.60	10.57	10.64
	(5.71)	(5.72)	(5.71)
Frequency of Social Activities Index	0.14	0.14	0.13
	(0.94)	(0.95)	(0.93)
Number of Sports Practiced	1.24	1.36	1.12
	(2.43)	(2.58)	(2.26)
Prob Extracurricular Activities	0.35	0.31	0.39
	(0.48)	(0.46)	(0.49)
N observations	18,358	9,309	9,049
N individuals	11,627	5,918	5,709
N observations per individual	1.58	1.57	1.59

Standard errors in parentheses. The table presents the mean and standard deviation of some socio-demographic characteristics of children. The table presents summary statistics for the whole sample as well as for boys and girls separately.

the Lower Layer Super Output Area (LSOA) where children live. Using this information, we match the Understanding Society dataset with the data on digital transition deadlines. Finally, the Understanding Society survey contains information on children's eating habits, as well as on the activities in which they get involved, including social, extracurricular, and sports activities.

Table 1 presents the means and standard deviations of some socio-demographic and health characteristics of children, in column 1 for the sample as a whole, and in columns 2 and 3 for boys and girls separately.[9] As shown, boys and girls are very similar in most socio-demographic characteristics, although boys have a higher BMI and lower mental discomfort than girls. Moreover, boys and girls are equally likely to get involved in social activities, and boys practice more sports, but are less likely to participate in extracurricular educational activities than girls.

5. Results

5.1. TV viewing time

This section explores whether the digital switchover had an effect on television viewing time. To do so, we use our aggregate data on TV viewing time per week and estimate a specification identical to Eq. (1) but that uses as unit of analysis the region-week level, given the aggregate nature of the dataset. In particular, we use as dependent variable the average television viewing time per week by children in a region, and as independent variables a set of event dummies indicating the year relative to the switchover date in a region, year–week dummy variables to account for the fact that our time unit of analysis is at the week level, regional fixed effects

[9] The paper comprises two analyses, where we study the effect of the digital transition on obesity and mental well-being. Table 1 presents summary statistics for children who are part of any of the samples we use throughout the paper.

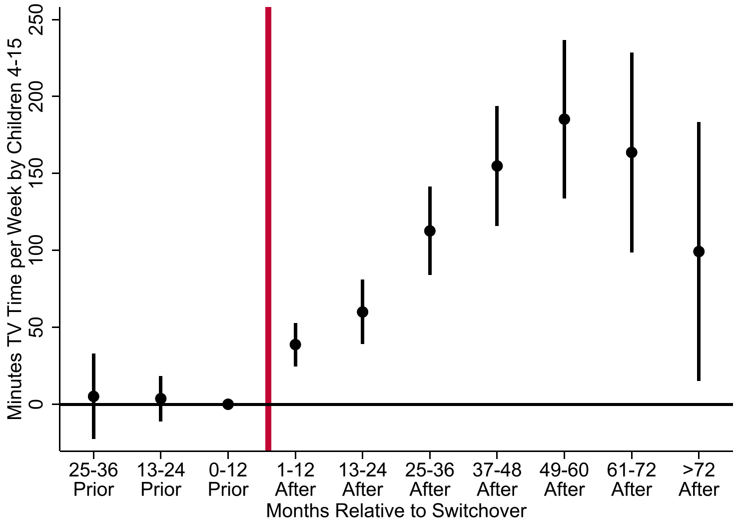

Fig. 4. TV Viewing Time. The figure presents the estimates and the 95 per cent confidence intervals of the event dummies of a specification identical to the baseline one but that uses as unit of analysis the region–week level, as it is the level at which we observe our aggregate dataset on TV viewing. We use children's average television viewing time per week in a region as dependent variable.

and regional trends.[10] We present the estimates in Fig. 4. As shown, the estimates on television viewing time per week before the switchover are very small and not statistically significant. However, right after the switchover, there is a rise in television viewing time per week and the impact increases over the years. The results therefore suggest parallel trends on television viewing time per week in the years before the switchover, and an increasing effect in the years after. Taking into account that a year has 52 weeks, we compute the magnitude of the total effect of the digital switchover on TV viewing time as the sum of the estimates of the event dummies for the years after the occurrence of the switchover multiplied by 52, and calculate that the digital switchover increased TV viewing time by 619.77 h per individual during the six years after the switchover. This represents an increase of 12.55% relative to the total TV viewing time per person over the same period.[11]

5.2. Baseline results

This section assesses the causal impact of the digital television switchover on mental health and obesity. To do so, panels A–B of Fig. 5 present the estimates of the baseline specification using as dependent variable a score that measures the overall mental discomfort of children and their BMI, respectively.[12] As shown, the estimates of the years preceding the switchover occurrence on mental well-being and obesity are small and not statistically significant. For mental health, however, the estimates of the years after the occurrence of the digital transition are positive and frequently statistically significant at the 5% confidence level, indicating that the digital transition increased mental discomfort. Regarding the dynamics of the effect on mental health, we find that the effect of having access to digital television signal on mental discomfort increases over time.[13] Regarding the magnitude of this impact, we

[10] We therefore estimate the following specification: $y_{r,t} = \alpha + \sum_{\tau \neq -1} \beta_\tau 1[\tau = t - t_r] + \lambda_t + \zeta_r + \zeta_r y + \varepsilon_{r,t}$. There are 52 weeks per year over the sample period, which goes from 2007 to 2014. $y_{r,t}$ is the average television viewing time per week of children in region r at year–week t; $\sum_{\tau \neq -1} 1[\tau = t - t_r]$ are our event dummies of interest indicating the years relative to the switchover date in region r; λ_t is a set of year–week dummies (8 years x 52 weeks per year dummies); ζ_r and $\zeta_r y$ are a set of region dummies and region trends over the years, respectively; and $\varepsilon_{r,t}$ is the error term.

[11] Appendix A.4 studies whether the digital switchover also had an impact on TV content. This is important because the new TV channels brought by the digital switchover may have increased the availability of TV content appealing to children. Besides, different TV content categories may have different effects on health. As shown in Appendix A.4, the estimates of the digital switchover on the type of television content that children watch are small, and also generally not statistically significant. This suggests that, despite the digital transition increased the number of TV channels and variety in TV programs that children could watch, children watched similar TV content before and after the switchover.

[12] Appendix A.5 repeats this analysis, but controlling for a dummy that takes value 1 if the switchover has occurred by the time of the interview in region r and 0 otherwise, instead of controlling for a set of event dummies. This functional form allows for a simpler presentation of the results but at the same time imposes the effects of the switchover to be constant over time, which may lead to the estimates obtained in Appendix A.5 being biased.

[13] In the baseline specification, we account for treatment heterogeneity over time. In Appendix A.6, we assess how important is treatment heterogeneity across units in our analysis and follow Sun and Abraham (2020) to estimate a DID model based on an interaction weighted estimator which presents estimates that are robust to treatment heterogeneity across units. As shown in Appendix A.6, the estimates of our analysis are robust to implementing this type of estimator.

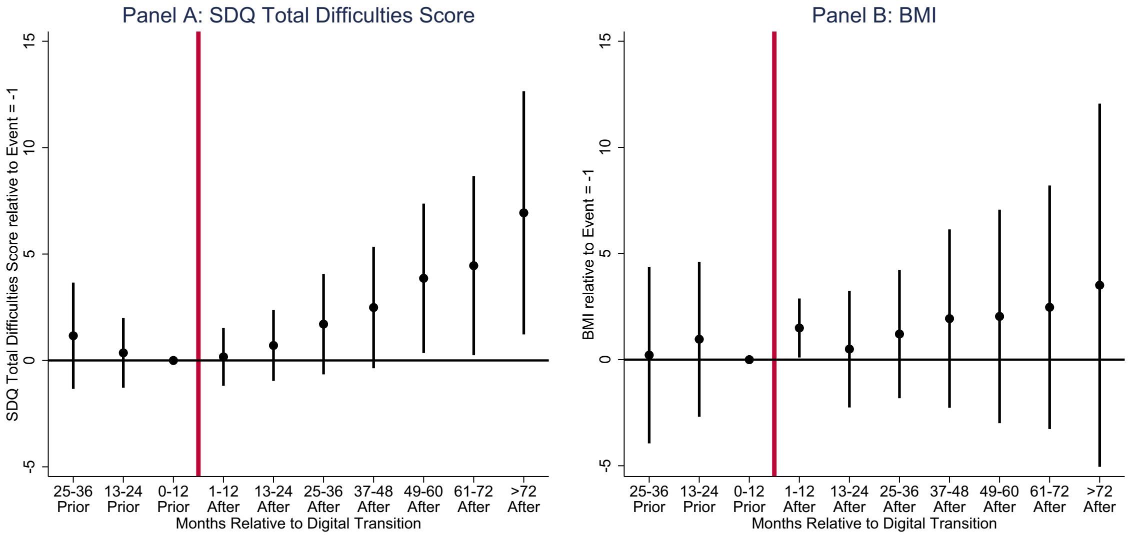

Fig. 5. Baseline Results. Panels A–B of the figure present the estimates of the event dummies of the baseline specification using as dependent variable the overall mental health discomfort score and BMI of children, respectively. We present 95 per cent confidence intervals after clustering standard errors at the LSOA level.

show that six years after the occurrence of the switchover, the mental discomfort score is 4.46 points higher relative to the year prior to the switchover. Taking into account that the switchover increased television viewing time by 619.77 h during this period, the estimates imply that 52 more hours of television viewing time (or one more hour per week during a year) lead to an increase in the mental health discomfort score of 0.374 points, which represents an increase of 3.53% relative to the average baseline level of this index for children. For physical health, we find suggestive evidence that children's BMI could have increased as a result of the digital transition.[14] Regarding the dynamics and magnitude of the effect of the digital switchover on BMI, we find that the effect seems to accumulate over time, but that the estimates are only statistically significant at the 5% confidence level in the short-term, possibly due to a lack of statistical power to estimate subsequent event dummy years.[15] We calculate the magnitude of the effect of exposure to television on BMI in a similar way as we did for mental health, and find that 52 more hours of television viewing time (or one more hour per week during a year) potentially increase BMI for children by 0.21 points, which would represent an increase of 1.04% in their average baseline level of BMI. While as mentioned above, the previous evidence of observational studies offers mixed results (Biddle et al., 2017), our estimates are within the range of magnitudes found by some of the previous longitudinal studies that did detect a positive association between TV viewing and BMI.[16] Further below, we examine which type of activities may have been replaced by TV viewing, in order to understand potential mechanisms behind our findings on the effects of exposure to television on mental health and BMI.

Fig. 6 examines which are the sub-components of the overall mental discomfort score of children driving the effect of the switchover on mental well-being. There are four sub-components of the overall mental discomfort score of children, which are: (i) conduct, (ii) emotional, (iii) hyperactivity, and (iv) relationship problems sub-score, respectively. As shown, we find small and not statistically significant estimates for all of these outcomes in the years preceding the switchover. However, we find that obtaining access to digital signal negatively affects the conduct of children, their emotional symptoms, hyperactivity, and relationship abilities. The estimates of the years after the occurrence of the switchover on these sub-components are generally significant or almost significant at the 5% confidence level, and consistent with the estimates for mental health in Fig. 5, we find an effect that increases over time for

[14] We test two main hypotheses in the paper, and hence it is important to account for multiple hypothesis testing in our baseline results. We address this concern in Appendix A.7.

[15] Appendix A.8 re-estimates the analysis on BMI presented in this section but using BMI z-scores as dependent variable. As shown, the estimates presented in Appendix A.8 are similar to the ones presented in this section.

[16] For instance, using a cohort of Australian children aged 7–15 years old, Cleland et al. (2018) found one extra hour per day of TV viewing to be associated with a BMI increase of 0.41 kg/m2, compared to those whose TV viewing remained stable. The longitudinal study by Danner (2008), focusing on a sample of US Kindergarten children, concluded that a child that watched four hours per day rather than one hour had an estimated 0.42 kg/m2 higher BMI. As the studies themselves acknowledge (and as we flagged in the literature review in Section 2), the existing longitudinal studies have hitherto not addressed the causal nature of the relationship of interest.

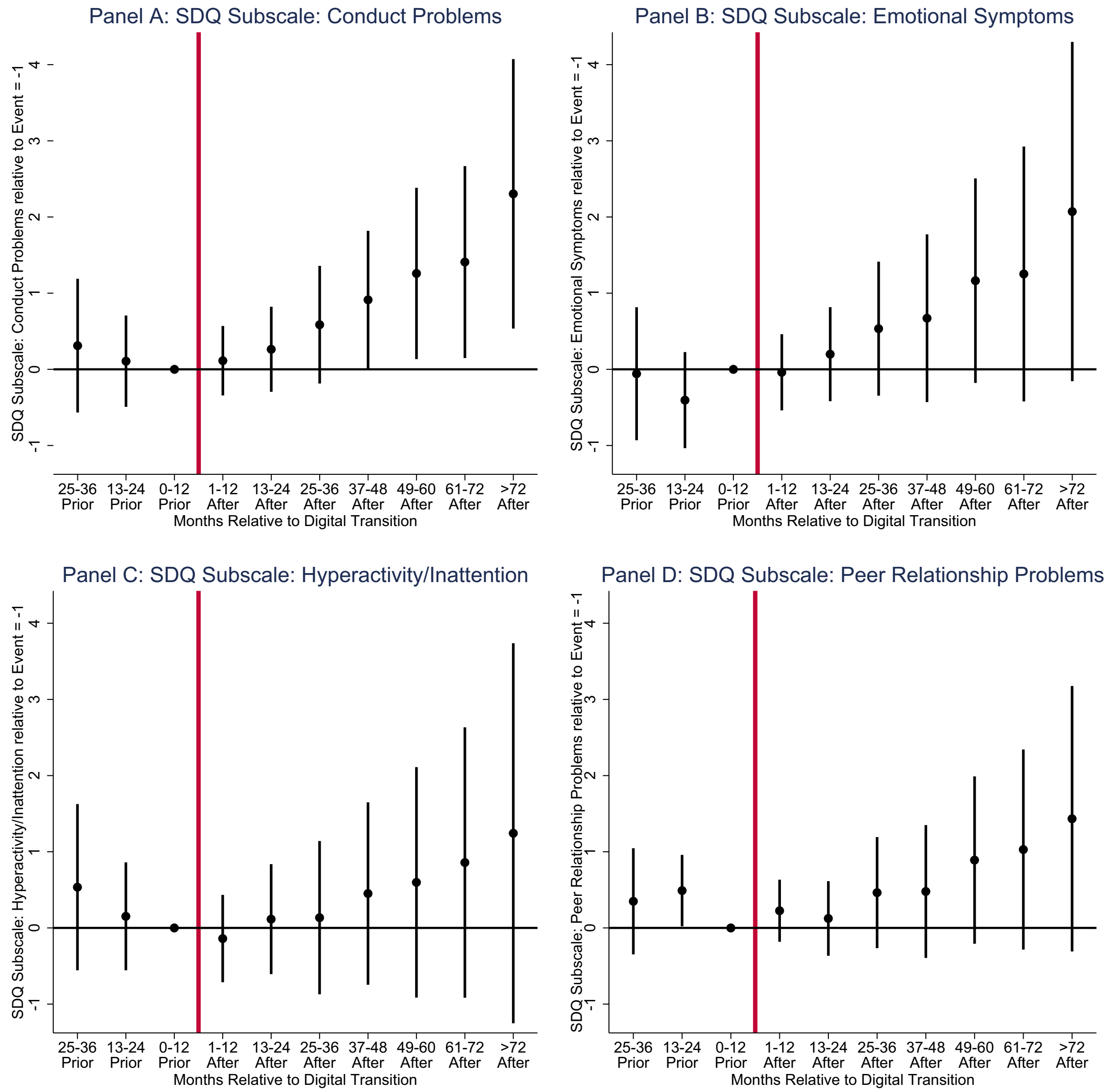

Fig. 6. Baseline Results–Mental Health Sub-components. Panels A–D of the figure present the estimates of the event dummies of the baseline specification using as dependent variable the (i) emotional, (ii) relationship, (iii) conduct, and (iv) hyperactivity mental discomfort score sub-components of children, respectively. We present 95 per cent confidence intervals after clustering standard errors at the LSOA level.

all outcomes. Lastly, we find higher effects of the switchover on mental health for the conduct problems and emotional symptoms sub–components.[17] Overall, the estimates suggest that television has a negative impact on the mental well-being of children.[18]

[17] When estimating these results, we have included all individuals available for each outcome variable. There are 26 individuals, however, who we can observe for some of the mental health sub-components, but not for all of them, and neither for the overall mental health discomfort score. Appendix A.9 re-estimates the analysis on mental health using the sample of individuals that we can observe in all mental health sub-components and in the overall mental health discomfort score. As shown, the estimates are robust to this sample restriction, which is not surprising given that it only drops 0.19% of the sample.

[18] Appendix A.10 shows that the inclusion of children fixed effects increases the width of the confidence intervals of our estimates, which was expected because we only observe children for an average of 1.62 and 1.48 times in the mental health and BMI analyses, respectively. Yet, it is reassuring to see that controlling for children fixed effects leads to similar results as the ones obtained in our baseline specification and to estimates that are almost significant at the 5% confidence level for the years after the switchover in some outcomes.

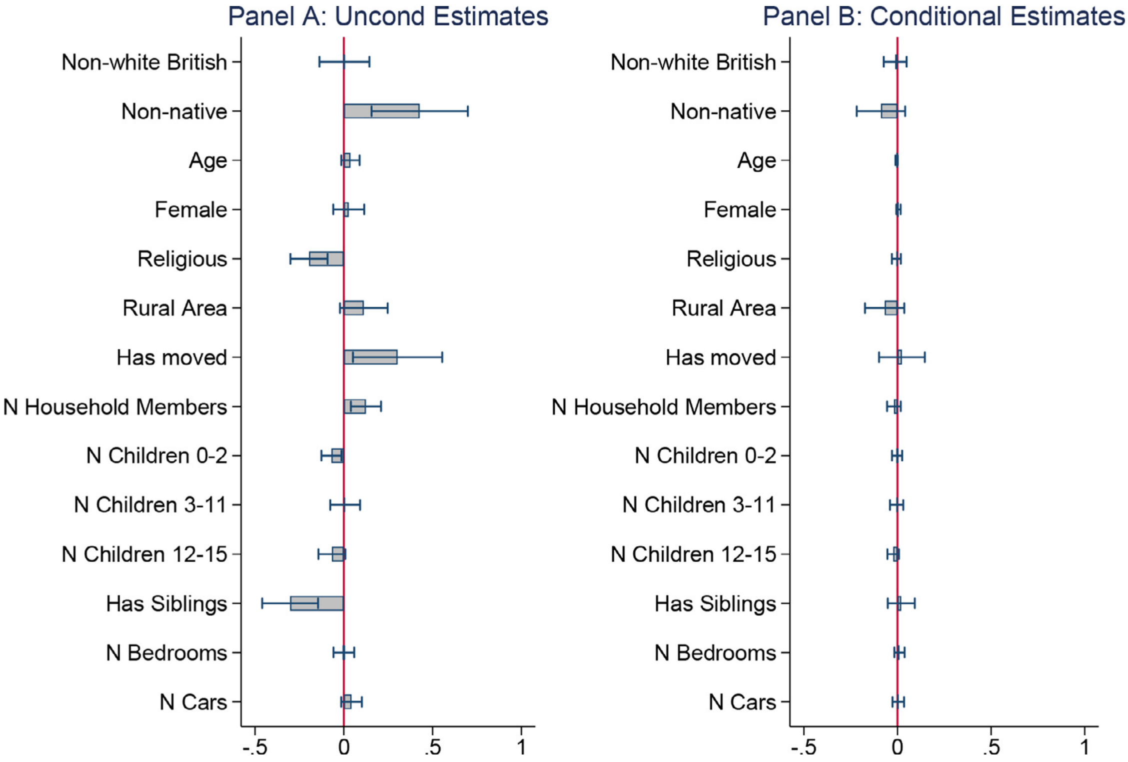

Fig. 7. Balancing Tests. The figure presents the estimates of a regression that studies whether a set of pre-determined characteristics are correlated with the timing of the digital television transition in the UK. Panel A presents unconditional estimates whereas panel B shows estimates after controlling for LSOA and year dummies.

5.3. Robustness checks

This section estimates multiple robustness checks to support the identification strategy and test whether the estimates are robust to different estimation specifications.

5.3.1. Balancing tests

We next provide evidence supporting our empirical strategy by examining whether the timing of the digital transition is correlated with a set of pre-determined characteristics that may be determinants of health outcomes. Panel A of Fig. 7 presents the unconditional estimates of a regression that studies the impacts of multiple pre-determined characteristics on the number of years that have passed at the time of the interview since the switchover deadline. Panel B of Fig. 7 presents the estimates of a regression similar to the one we estimate in panel A but that controls for LSOA and year dummies. The timing of the digital transition is unconditionally correlated with some pre-determined characteristics, but all the estimates become small and not statistically significant after controlling for LSOA and year dummies.

5.3.2. Alternative specifications

We next account for the fact that children receiving television signal from different transmitters may differ in unobserved characteristics that determine mental health and BMI. To do so, Fig. 8 presents the estimates of a specification similar to the baseline one but that also controls for a set of transmitter dummies. We use as dependent variables children's mental discomfort score and BMI in panels A and B, respectively. As shown, the event dummies estimates are similar to the ones we found after estimating our baseline specification, and so the estimates of the digital transition are robust to controlling for transmitter fixed effects.

5.4. Heterogeneity

In this sub-section, we study whether the impacts of the digital transition on mental well-being and BMI are heterogeneous in the socio-demographic characteristics of children. Fig. 9 presents the estimates of specification 1 separately for the subsamples of individuals with a household income below and above the median of the household income distribution. We use as dependent variable children's overall mental discomfort index in panels A–B, and BMI in panels C–D. As shown, the estimates of the event dummies preceding the switchover date are small and not statistically significant for individuals independently of their household income. Moreover, the effects of exposure to television on mental well-being and BMI are similar for children of different socio-economic

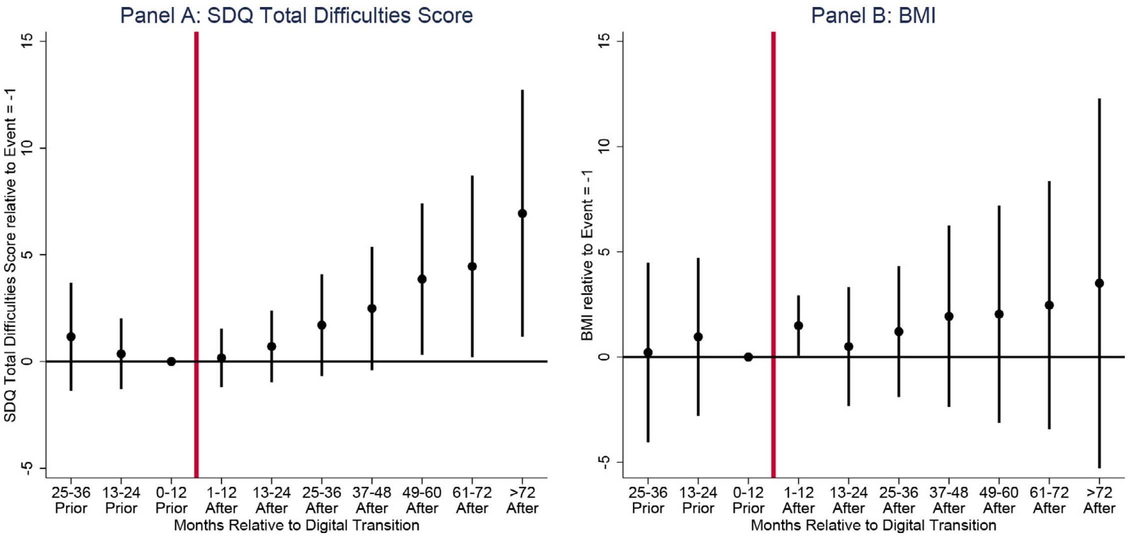

Fig. 8. Alternative Specification. The figure presents the estimates of the event dummies of a model similar to the baseline specification but that also controls for transmitter fixed effects. Panels A–B of the Figure use as dependent variable the overall mental health discomfort score and BMI of children, respectively. We present 95 per cent confidence intervals after clustering standard errors at the LSOA level.

backgrounds, as the estimates are not statistically different across subgroups. This may be because, in this section, we estimate our baseline specification based on subgroups of the population, which have reduced sample sizes and may lead to a lack of statistical power in our estimations.

We further examine whether the effects of the digital television transition on mental well-being and BMI are heterogeneous in children's gender. We do so by estimating the baseline specification separately for boys and girls. Panels A–B and C–D of Fig. 10 present the estimates using children's total mental difficulties score and BMI as dependent variable, respectively. As shown, the estimates on the years preceding the switchover are small and not statistically significant in all panels. Moreover, we show that the baseline results on the effect of the switchover on mental well-being and BMI are primarily driven by boys, albeit the point estimates are not statistically different by gender.

Lastly, we study whether the effects of exposure to television on mental well-being and BMI are heterogeneous in children's ethnicity. We do so by estimating the baseline specification separately for white British and non-white British. Panels A–B and C–D of Fig. 11 present the estimates using children's total mental difficulties score and BMI as dependent variable, respectively. As shown, the point estimates of the years preceding the arrival of digital signal are small and not statistically significant. Moreover, the estimates of the years after the switchover are not statistically different between white British and non-white British, suggesting that the effects of the digital transition on mental well-being and BMI do not depend on children's ethnicity.

It is also important to note that previous studies have found that the labour status of parents matters for the probability of children being overweight (Li et al., 2019). Appendix A.11 explores whether parents' labour status also plays a role in our context, and shows that the effects of exposure to television on mental health and obesity do not depend on parents' employment situation.

6. Mechanisms

This section explores the type of activities that the increased exposure to television replaced as potential mechanisms behind the impact of television on mental well-being and BMI. We explore the effect of exposure to television on time allocation across three main dimensions: (i) social activities, (ii) sports and (iii) extracurricular educational activities.

First, to explore whether television changes the time that children dedicate to social activities, we estimate the baseline specification and use as dependent variable a standardized version of an index that originally adds the frequency with which children get involved in all the activities available in the dataset in which children are likely to interact with others. All these activities are measured in a scale that ranges from 1 (never) to 6 (most days), and are: going to (i) a party (ii) cinema, (iii) theater, (iv) live sports events, (v) pub/bar, (vi) youth club, (vii) library, (viii) museum, (ix) historical place, hanging around (x) near home, (xi) in their town centre, and (xii) doing voluntary services. In theory, if children spend less time in social activities as a response to increased television exposure, this may have detrimental effects for their mental well-being. Moreover, by reducing the time children spend in social activities, they may also be less physically active, which may increase their BMI. Panel A of Fig. 12 presents the estimates and shows that the digital transition reduced the frequency of children getting involved in social activities. We find that this impact accumulates over time, consistent with our baseline estimates on the detrimental effects of exposure to television on mental well-being and BMI. It is also important to note that this section uses standardized dependent variables to allow for a greater comparability of the estimates across mechanisms. To examine the magnitude of the effect of the switchover on social activities, Appendix A.12 repeats the analysis of this section using the original index variables as dependent outcomes. Taking into account that we found that

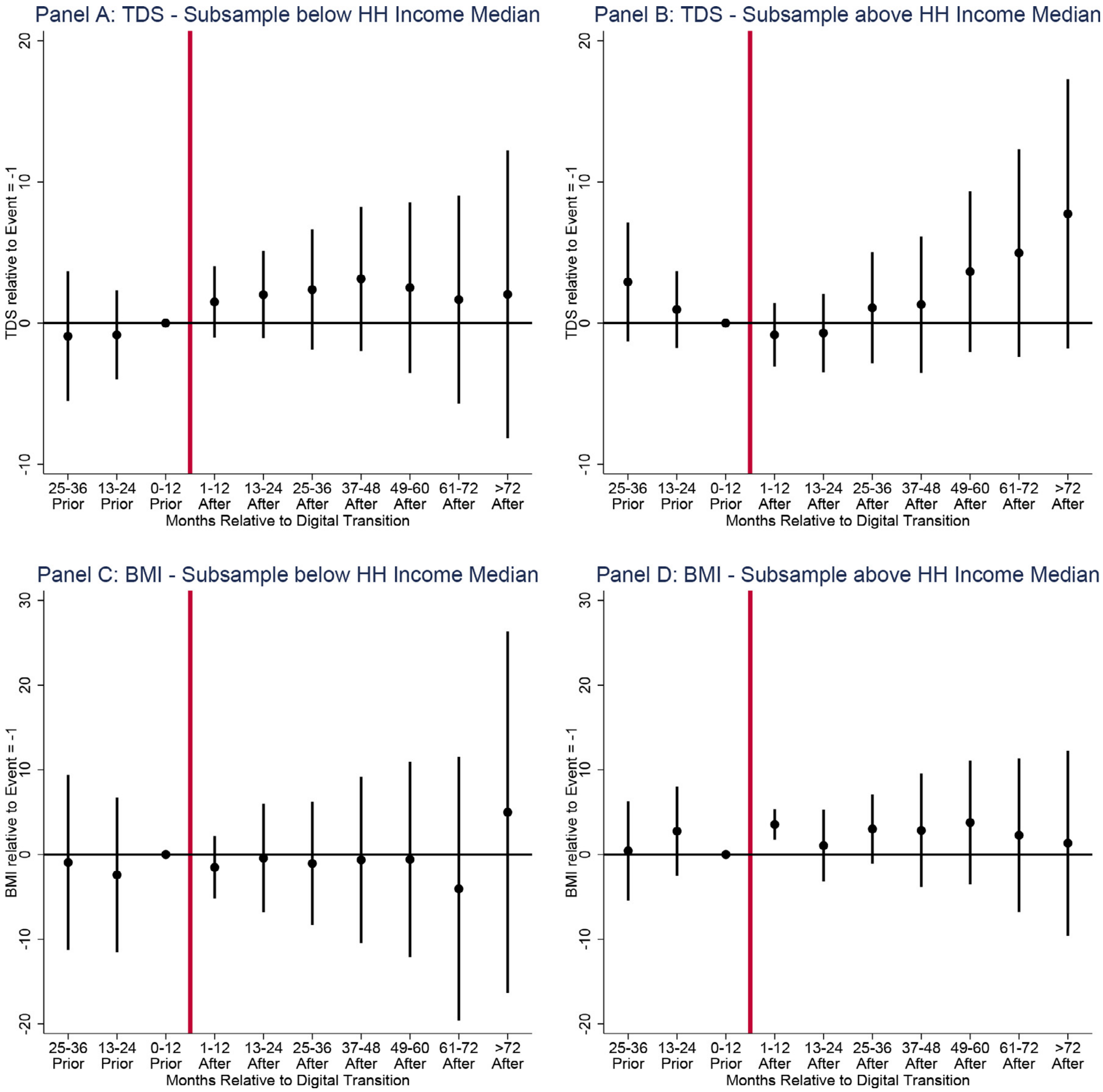

Fig. 9. Heterogeneity in Income. The figure presents the estimates of the event dummies of the baseline specification separately for the subsamples with a household income below and above the median. We use as dependent variable children's overall mental discomfort score in panels A–B, and BMI in panels C–D. We present 95 per cent confidence intervals after clustering standard errors at the LSOA level.

the switchover increased TV viewing time by 619.77 h per individual in the six years after its occurrence, we compute that, 52 more hours of TV viewing (or one extra hour per week during a year) reduces children's involvement in social activities by 0.50 points six years after the switchover, which represents a decrease of 0.90% relative to the average baseline level of this index. Appendix A.13 provides further evidence on whether the reduction in social activities as a response of the digital switchover indeed led to a decrease in social abilities and interactions for children. As shown, the digital transition reduced the frequency of children reporting that they are liked by others of their age as well as their number of friends.

Second, we explore whether television changes children's physical activity by estimating the baseline specification and using as dependent variable a standardized version of an index that originally adds indicators on whether children mention doing the following exercises: (i) walking, (ii) swimming, (iii) cycling, (iv) running/jogging, (v) tennis/squash, (vi) aerobics, (vii) football, (viii) rugby, (ix) basketball/netball, (x) cricket, (xi) athletics, (xii) martial arts, (xiii) horse riding, (xiv) gymnastics, (xv) dancing, and (xvi) other sport. In principle, if exposure to television reduces the frequency of children doing sports, the increased sedentary behaviour may lead to an increase in BMI and mental discomfort. Panel B of Fig. 12 presents the estimates and shows that indeed the digital transition reduced the frequency of children getting involved in sports. Using the estimates in panel B of Appendix A.12 and the magnitude of the effect of the switchover on TV viewing time, we calculate that 52 more hours of TV viewing (or one extra hour per week during

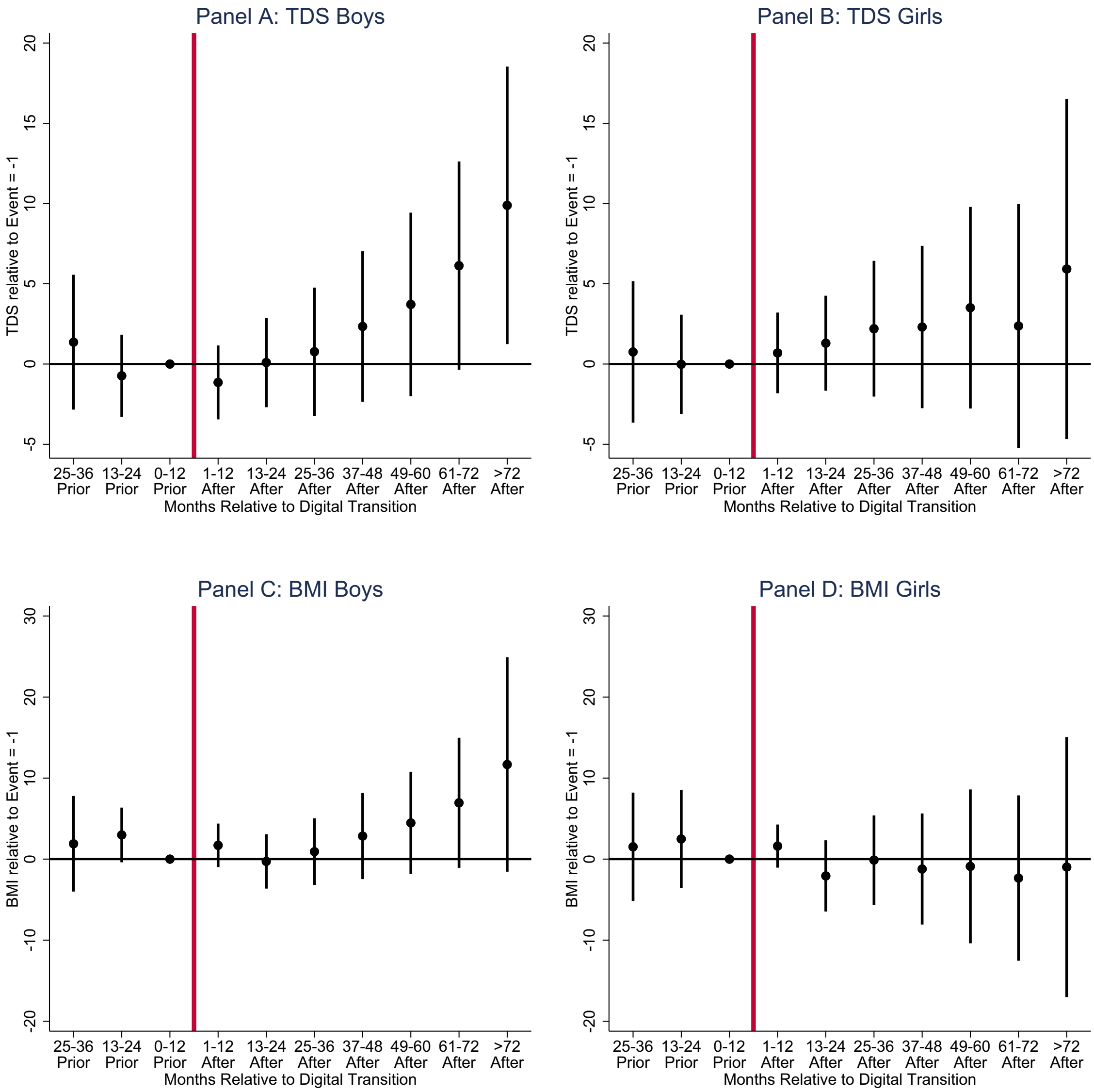

Fig. 10. Heterogeneity in Gender. The figure presents the estimates of the event dummies of the baseline specification separately for boys and girls. Panels A–B use as dependent variable the overall mental discomfort score of children, while panels C–D use as dependent variable BMI for children. We present 95 per cent confidence intervals after clustering standard errors at the LSOA level.

a year) decreases the number of sports that children practice by 0.03, which represents a decrease of 1.25% relative to the average baseline level of the sports index.

Lastly, we explore whether exposure to television changes the probability of children getting involved in extracurricular educational activities by using as dependent variable the likelihood of children reporting that they regularly attend any of the following classes: (i) music, (ii) arts, (iii) tutorials for school subjects, and (iv) religious classes. In theory, watching television is worse for children's cognitive development relative to attending the aforementioned extracurricular and cultural activities. Panel C of Fig. 12 presents the estimates, and shows that the digital switchover had no impact on the probability of children attending extracurricular educational activities.

Taking all the previous findings together, this section has shown that one more hour of television viewing per week during a year decreases the frequency of children getting involved in social and sports activities by 0.9% and 1.25%, respectively. This may explain, at least in part, our baseline results on one more hour of television viewing per week during a year increasing mental discomfort and BMI for children by 3.53% and 1.04%, respectively.[19]

[19] In appendix A.14, we also explore whether the effect of exposure to television on children's mental well-being and BMI may be due to changes in their eating habits or personal views about their appearance, but we do not find evidence on these being the case.

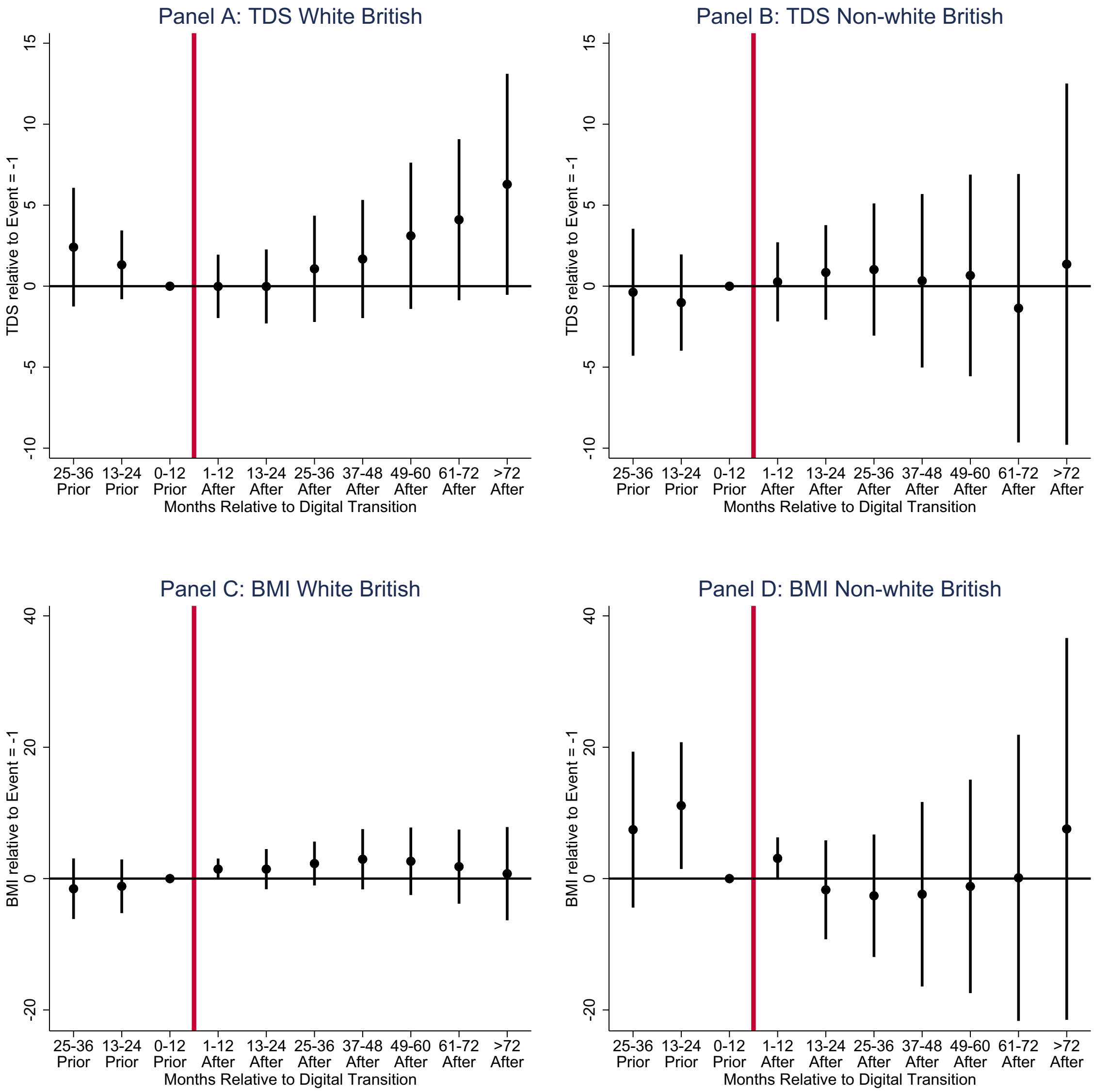

Fig. 11. Heterogeneity in Ethnicity. The figure presents the estimates of the event dummies of the baseline specification separately for white British and non-white British. Panels A–B use as dependent variable the overall mental discomfort score of children, while panels C–D use as dependent variable BMI for children. We present 95 per cent confidence intervals after clustering standard errors at the LSOA level.

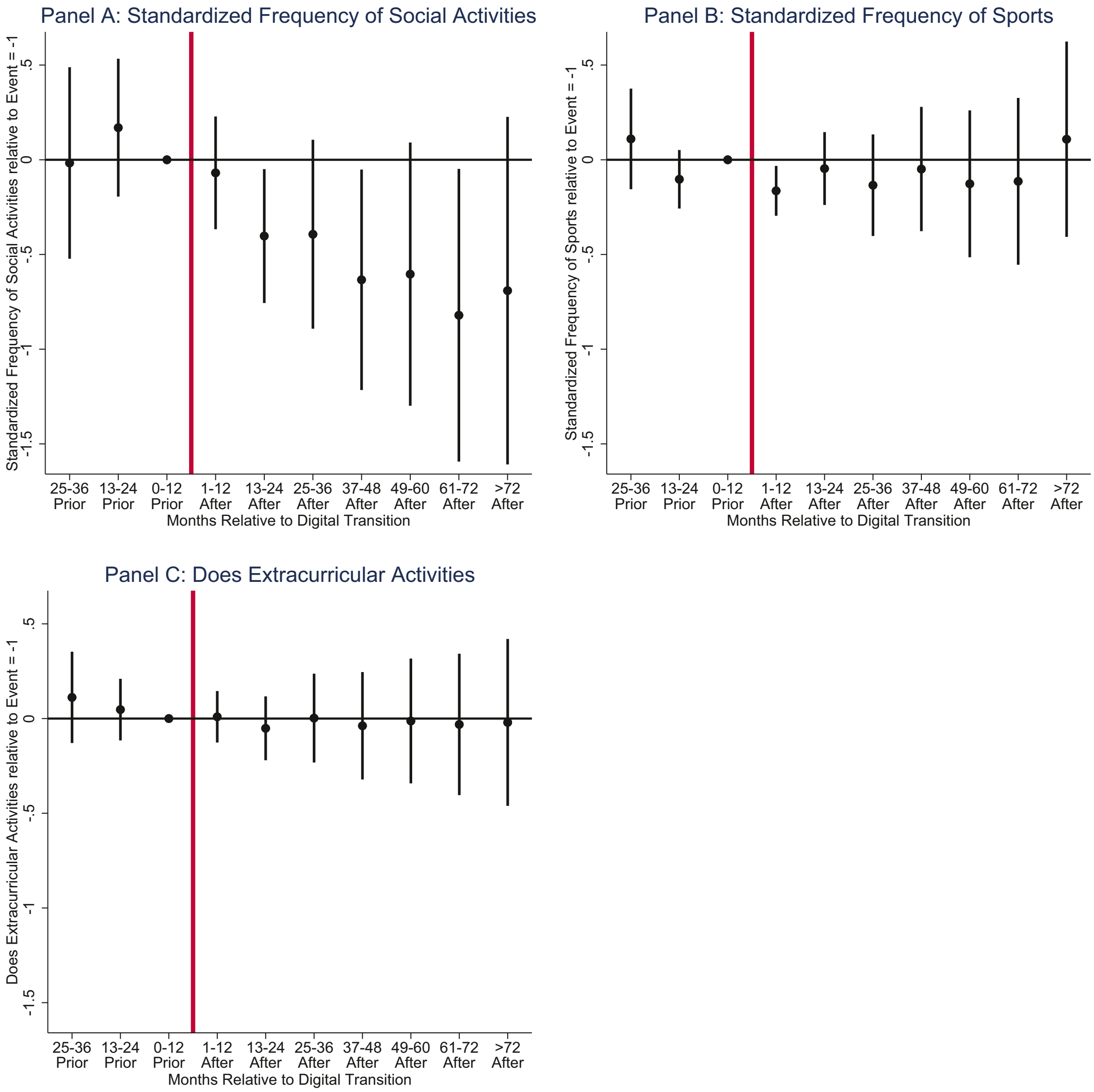

Fig. 12. Mechanisms–Social, Sports and Extracurricular Educational Activities. Panels A–C of the figure present the estimates of the event dummies of the baseline specification using as dependent variable an index of the frequency of children getting involved in (i) social and (ii) sports activities, as well as (iii) the probability of children regularly attending extracurricular educational activities, respectively. We standardize non–binary outcome variables to allow for a greater comparability across panels. We present 95 per cent confidence intervals after clustering standard errors at the LSOA level.

7. Conclusions

This paper has contributed evidence on the causal impacts of exposure to television on children's mental well-being and BMI, using the digital television transition in the UK as a natural experiment. The digital switchover consisted in the transformation of every television transmitter in the UK to cease the broadcast of analogue television signal and start the provision of high power digital signal. The reform gave access to digital television signal to millions of households, increasing the number of television channels they could watch from 5 to 40. The digital transition took place during the period of 2008–2012 in stages across the different areas of the UK, and we exploit variation in the switchover dates across more than 40,000 geographical units.

Using an aggregate panel dataset containing information on TV viewing for the different TV regions in the UK, an individual panel dataset containing annual information on the health characteristics of children and an event study model that exploits variation in the dates when the digital transition occurs in the different UK areas, we provide causal evidence on the effects of the digital transition on TV viewing time, mental well-being, and BMI. First, we find that TV viewing time does not change in the years prior to the digital transition, suddenly increases right after the switchover introduction, and that this impact is increasing over time. Second, we show that child mental health and BMI do not change in the years prior to the switchover, but that the digital transition worsens the mental well-being of children considerably, and that the effect is increasing over time. We also find suggestive evidence that the switchover could have increased children's BMI. We test for potential channels behind the effects of the digital transition on mental well-being and BMI, and show that the switchover reduces the frequency with which children participate in social and physical activities. In contrast, we do not find evidence supporting changes in children's eating habits, perceptions about appearance and involvement in extracurricular educational activities as a response of an increased exposure to television.

As this paper focuses on the effects of television, one might question the true relevance of the findings, given that the time children dedicate to television viewing has decreased during the last years. First, while we acknowledge that television watching has indeed recently decreased, it is also true that this reduction has been slow, and that the time that children spend in front of the TV remains substantial. Following a report from Ofcom, children aged 12–15 dedicated on average 13.25 h per week to watch television in the UK in 2018. Second, the decrease in television viewing time through a television set has been compensated by a rise in the time that children dedicate to watch internet-based streaming services, such as Youtube, Netflix or Amazon Prime video, which is an activity very similar if not identical to television watching. In particular, both television viewing and internet-based streaming services viewing are types of screen watching that involve increased sedentary behaviour. Moreover, both an increase in TV viewing and internet-based streaming services viewing are likely to replace the same type of activities for children (sports and social activities). Thus, both TV and internet-based streaming viewing are likely to have similar health consequences, and therefore the estimates provided in this paper should be relevant to evaluate the effect of other types of screen watching activities that have recently become very popular on children's health.

Based on our results, policymakers should seriously consider policies that reduce children's access to television (and likely similar media) as potentially promising means of improving children's health.

Declaration of Competing Interest

None.

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Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jhealeco.2021.102543

References

Andreyeva, T., Kelly, I.R., Harris, J.L., 2011. Exposure to food advertising on television: associations with children's fast food and soft drink consumption and obesity. Econ. Hum. Biol. 9 (3), 221–233.
Angrist, J.D., Pischke, J.-S., 2008. Mostly Harmless Econometrics: an Empiricist's Companion. Princeton University Press.
Avery, A., Anderson, C., McCullough, F., 2017. Associations between children's diet quality and watching television during meal or snack consumption: a systematic review. Matern. Child Nutr. 13 (4), e12428.
Barone, G., D'Acunto, F., Narciso, G., 2015. Telecracy: testing for channels of persuasion. Am. Econ. J. 7 (2), 30–60.
Biddle, S.J., Bengoechea, E.G., Wiesner, G., 2017. Sedentary behaviour and adiposity in youth: a systematic review of reviews and analysis of causality. Int. J. Behav. Nutr.Phys. Act. 14 (1), 43.
Biddle, S.J., Petrolini, I., Pearson, N., 2014. Interventions designed to reduce sedentary behaviours in young people: a review of reviews. Br. J. Sports Med. 48 (3), 182–186.
Blakemore, S.-J., 2019. Adolescence and mental health. Lancet 393 (10185), 2030–2031.
Boone, J.E., Gordon-Larsen, P., Adair, L.S., Popkin, B.M., 2007. Screen time and physical activity during adolescence: longitudinal effects on obesity in young adulthood. Int. J. Behav. Nutr.Phys. Act. 4 (1), 26.
Bryant, J., Carveth, R.A., Brown, D., 1981. Television viewing and anxiety: an experimental examination. J. Commun. 31 (1), 106–119. doi:10.1111/j.1460-2466.1981.tb01210.x.
Buchanan, L.R., Rooks-Peck, C.R., Finnie, R.K., Wethington, H.R., Jacob, V., Fulton, J.E., Johnson, D.B., Kahwati, L.C., Pratt, C.A., Ramirez, G., et al., 2016. Reducing recreational sedentary screen time: a community guide systematic review. Am. J. Prevent. Med. 50 (3), 402–415.
Van den Bulck, J., Van Mierlo, J., 2004. Energy intake associated with television viewing in adolescents, a cross sectional study. Appetite 43 (2), 181–184.
Chou, S.-Y., Rashad, I., Grossman, M., 2008. Fast-food restaurant advertising on television and its influence on childhood obesity. J. Law Econ. 51 (4), 599–618.
Christakis, D.A., Zimmerman, F.J., DiGiuseppe, D.L., McCarty, C.A., 2004. Early television exposure and subsequent attentional problems in children. Pediatrics 113 (4), 708–713.
Christakis, N.A., Fowler, J.H., 2007. The spread of obesity in a large social network over 32 years. N. Engl. J. Med. 357 (4), 370–379.
Cleland, V.J., Patterson, K., Breslin, M., Schmidt, M.D., Dwyer, T., Venn, A.J., 2018. Longitudinal associations between tv viewing and BMI not explained by the 'mindless eating' or 'physical activity displacement' hypotheses among adults. BMC Public Health 18 (1), 1–12.
Crespo, C.J., Smit, E., Troiano, R.P., Bartlett, S.J., Macera, C.A., Andersen, R.E., 2001. Television watching, energy intake, and obesity in US children: results from the third national health and nutrition examination survey, 1988–1994. Arch. Pediatr. Adolesc. Med. 155 (3), 360–365.
Currie, J., 2009. Healthy, wealthy, and wise: socioeconomic status, poor health in childhood, and human capital development. J. Econ. Lit. 47 (1), 87–122.
Currie, J., Stabile, M., 2006. Child mental health and human capital accumulation: the case of adhd. J. Health Econ. 25 (6), 1094–1118.
Danner, F.W., 2008. A national longitudinal study of the association between hours of tv viewing and the trajectory of BMI growth among us children. J. Pediatr. Psychol. 33 (10), 1100–1107.

Dennison, M., Sisson, S.B., Morris, A., 2016. Obesogenic behaviours and depressive symptoms in children: a narrative literature review. Obes. Rev. 17 (8), 735–757.
Dickson, K., Richardson, M., Kwan, I., MacDowall, W., Burchett, H., Stansfield, C., Brunton, G., Sutcliffe, K., Thomas, J., 2018. Screen-based activities and children and young people's mental health and psychosocial wellbeing: a systematic map of reviews.
Dietz, W.H., Gortmaker, S.L., 1985. Do we fatten our children at the television set? obesity and television viewing in children and adolescents. Pediatrics 75 (5), 807–812.
DigitalUK, 2012. Digital TV switchover 2008–2012. Final report.
Duflo, E., Glennerster, R., Kremer, M., 2007. Using randomization in development economics research: a toolkit. Handb. Dev. Econ. 4, 3895–3962.
DuRant, R.H., Baranowski, T., Johnson, M., Thompson, W.O., 1994. The relationship among television watching, physical activity, and body composition of young children. Pediatrics 94 (4), 449–455.
Fletcher, J.M., 2014. The effects of childhood adhd on adult labor market outcomes. Health Econ. 23 (2), 159–181.
Frijters, P., Hatton, T.J., Martin, R.M., Shields, M.A., 2010. Childhood economic conditions and length of life: evidence from the uk boyd orr cohort, 1937–2005. J. Health Econ. 29 (1), 39–47.
Gentzkow, M., Shapiro, J.M., 2008. Preschool television viewing and adolescent test scores: historical evidence from the Coleman study. Q. J. Econ. 123 (1), 279–323.
Geserick, M., Vogel, M., Gausche, R., Lipek, T., Spielau, U., Keller, E., Pfäffle, R., Kiess, W., Körner, A., 2018. Acceleration of BMI in early childhood and risk of sustained obesity. N. Engl. J. Med..
Ghobadi, S., Hassanzadeh-Rostami, Z., Salehi-Marzijarani, M., Bellissimo, N., Brett, N., Totosy de Zepetnek, J., Faghih, S., 2018. Association of eating while television viewing and overweight/obesity among children and adolescents: a systematic review and meta-analysis of observational studies. Obes. Rev. 19 (3), 313–320.
Gortmaker, S.L., Must, A., Sobol, A.M., Peterson, K., Colditz, G.A., Dietz, W.H., 1996. Television viewing as a cause of increasing obesity among children in the united states, 1986–1990. Arch. Pediatr. Adolesc. Med. 150 (4), 356–362.
Hammer, L., Killen, J., Robinson, T., 1993. Does television viewing increase obesity and reduce physical activity? cross-sectional and longitudinal analyses among adolescent girls. Pediatrics 91, 273–280.
Hancox, R.J., Milne, B.J., Poulton, R., 2004. Association between child and adolescent television viewing and adult health: a longitudinal birth cohort study. Lancet 364 (9430), 257–262.
Harvey, S.B., Hotopf, M., Øverland, S., Mykletun, A., 2010. Physical activity and common mental disorders. Br. J. Psychiatry 197 (5), 357–364.
Hastings, G., Stead, M., McDermott, L., Forsyth, A., MacKintosh, A.M., Rayner, M., Godfrey, C., Caraher, M., Angus, K., 2003. Review of Research on the Effects of Food Promotion to Children. Food Standards Agency, London.
Hobbs, M., Pearson, N., Foster, P.J., Biddle, S.J., 2015. Sedentary behaviour and diet across the lifespan: an updated systematic review. Br. J. Sports Med. 49 (18), 1179–1188.
Huesmann, L.R., Moise-Titus, J., Podolski, C.-L., Eron, L.D., 2003. Longitudinal relations between children's exposure to tv violence and their aggressive and violent behavior in young adulthood: 1977–1992. Dev. Psychol. 39 (2), 201.
Jacka, F., Berk, M., 2007. Food for thought. Acta Neuropsychiatr. 19 (5), 321–323. doi:10.1111/j.1601-5215.2007.00246.x.
Jenvey, V.B., 2007. The relationship between television viewing and obesity in young children: a review of existing explanations. Early Child Dev. Care 177 (8), 809–820.
Johnson, J.G., Cohen, P., Kasen, S., First, M.B., Brook, J.S., 2004. Association between television viewing and sleep problems during adolescence and early adulthood. Arch. Pediatr. Adolesc. Med. 158 (6), 562–568.
Johnson, J.G., Cohen, P., Smailes, E.M., Kasen, S., Brook, J.S., 2002. Television viewing and aggressive behavior during adolescence and adulthood. Science 295 (5564), 2468–2471.
Katzmarzyk, P.T., Malina, R.M., Song, T.M., Bouchard, C., 1998. Television viewing, physical activity, and health-related fitness of youth in the quebec family study. J. Adolesc. Health 23 (5), 318–325.
Kearney, M.S., Levine, P.B., 2019. Early childhood education by television: lessons from sesame street. Am. Econ. J. 11 (1), 318–350.
Klesges, R.C., Shelton, M.L., Klesges, L.M., 1993. Effects of television on metabolic rate: potential implications for childhood obesity. Pediatrics 91 (2), 281–286.
Lechner, M., 2009. Long-run labour market and health effects of individual sports activities. J. Health Econ. 28 (4), 839–854.
Li, J., Kaiser, T., Pollmann-Schult, M., Strazdins, L., 2019. Long work hours of mothers and fathers are linked to increased risk for overweight and obesity among preschool children: longitudinal evidence from germany. J. Epidemiol. Community Health 73 (8), 723–729.
Lubans, D.R., Smith, J.J., Morgan, P.J., Beauchamp, M.R., Miller, A., Lonsdale, C., Parker, P., Dally, K., 2016. Mediators of psychological well-being in adolescent boys. J. Adolesc. Health 58 (2), 230–236.
Lundborg, P., Nilsson, A., Rooth, D.-O., 2014. Adolescent health and adult labor market outcomes. J. Health Econ. 37, 25–40.
Mastrorocco, N., Minale, L., 2018. News media and crime perceptions: evidence from a natural experiment. J. Public Econ. 165, 230–255. doi:10.1016/j.jpubeco.2018.07.002.
Nakamuro, M., Inui, T., Senoh, W., Hiromatsu, T., 2015. Are television and video games really harmful for kids? Contemp. Econ. Policy 33 (1), 29–43.
Nieto, A., 2019. Television, Time use and Academic Achievement: Evidence from a Natural Experiment. Granger Centre Discussion Paper 19/06.
Nikolaou, D., 2017. Does cyberbullying impact youth suicidal behaviors? J. Health Econ. 56, 30–46.
OECD, 2019a. Chapter 3. Trends in children's emotional well-being. https://www.oecd-ilibrary.org/sites/3b7cb397-en/index.html?itemid=/content/component/3b7cb397-en.
OECD, 2019b. Overweight and obesity among children. https://www.oecd-ilibrary.org/sites/010c22fe-en/index.html?itemid=/content/component/010c22fe-en.
Ofcom, 2019. Children and parents: media use and attitudes report 2018. https://www.ofcom.org.uk/research-and-data/media-literacy-research/childrens/children-and-parents-media-use-and-attitudes-report-2018.
Powell, L.M., Wada, R., Khan, T., Emery, S.L., 2017. Food and beverage television advertising exposure and youth consumption, body mass index and adiposity outcomes. Can. J. Econ. 50 (2), 345–364.
Robinson, T.N., 1999. Reducing children's television viewing to prevent obesity: a randomized controlled trial. JAMA 282 (16), 1561–1567.
Russell-Mayhew, S., McVey, G., Bardick, A., Ireland, A., 2012. Mental health, wellness, and childhood overweight/obesity. J. Obes. 2012.
Saffer, H., Dave, D., 2006. Alcohol advertising and alcohol consumption by adolescents. Health Econ. 15 (6), 617–637.
Sandercock, G.R., Ogunleye, A., Voss, C., 2012. Screen time and physical activity in youth: thief of time or lifestyle choice? J. Phys. Act. Health 9 (7), 977–984.
Smith, J.P., 2009. The impact of childhood health on adult labor market outcomes. Rev. Econ. Stat. 91 (3), 478–489.
van Strien, T., Cebolla, A., Etchemendy, E., Gutierrez-Maldonado, J., Ferrer-Garcia, M., Botella, C., Baños, R., 2013. Emotional eating and food intake after sadness and joy. Appetite 66, 20–25.
Sun, L., Abraham, S., 2020. Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. J. Econ..
Swinburn, B., Shelly, A., 2008. Effects of tv time and other sedentary pursuits. Int. J. Obes. 32 (7), S132–S136.
Tahir, M.J., Willett, W., Forman, M.R., 2019. The association of television viewing in childhood with overweight and obesity throughout the life course. Am. J. Epidemiol. 188 (2), 282–293.
Tammelin, T., Ekelund, U., Remes, J., Näyhä, S., 2007. Physical activity and sedentary behaviors among finnish youth. Med. Sci. Sports Exerc. 39 (7), 1067–1074.
Thompson, D.A., Christakis, D.A., 2005. The association between television viewing and irregular sleep schedules among children less than 3 years of age. Pediatrics 116 (4), 851–856. doi:10.1542/peds.2004-2788. https://pediatrics.aappublications.org/content/116/4/851.full.pdf
Tripathi, M., Mishra, S.K., 2020. Screen time and adiposity among children and adolescents: a systematic review. J. Public Health 28 (3), 227–244.
University of Essex, Institute for Social and Economic Research. (2019a). Understanding Society: Waves 1–9, 2009–2018 and Harmonised BHPS: Waves 1–18, 1991–2009. [data collection]. 12th Edition. UK Data Service. SN: 6614, 10.5255/UKDA-SN-6614-13.
de Wit, L., van Straten, A., Lamers, F., Cuijpers, P., Penninx, B., 2011. Are sedentary television watching and computer use behaviors associated with anxiety and depressive disorders? Psychiatry Res. 186 (2–3), 239–243.
Zhang, G., Wu, L., Zhou, L., Lu, W., Mao, C., 2016. Television watching and risk of childhood obesity: a meta-analysis. Eur. J. Public Health 26 (1), 13–18.

University of Essex, Institute for Social and Economic Research (2019b). Understanding Society: Waves 1–9, 2009–2018: Special Licence Access, Census 2011 Lower Layer Super Output Areas. [data collection]. 9th Edition. UK Data Service. SN: 7248, 10.5255/UKDA-SN-7248-9.